SALT SPRAY INJURY STUDY:

EFFICACY OF FILM-FORMING CHEMICALS FOR PROTECTING ROADSIDE TREES

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Environment Ontario

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FOR PROTECTING ROADSIDE TREES

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Previous studies showed that five film-forming chemicals, Folicote, RD 1725, RD 1726, Siliconate 51T and Joncryl 1938, were the most effective of 18 products in protecting fruit and landscape trees against salt spray injury (Piedrahita 1987).

In an additional year of field testing, these five chemicals were sprayed on selected branches of peach trees in November, 1987. This experiment also included a control (unsprayed) treatment and another in which branches were covered with burlap. Trees were evaluated in the spring of 1988 for Na^+ and Cl^- content in twigs and the amount of twig injury. Control twigs accumulated 358 ppm Cl^- and had the greatest injury (13.6 cm dieback to the first flowerbud). Burlapped twigs accumulated only 58 ppm Cl^- and were the least damaged (5.3 cm dieback). All spray-treated twigs contained between 248-290 ppm Cl^- and had intermediate injury. Among spray treatments, the least dieback occurred with RD 1726 (8.7 cm) and Joncryl 1938 (7.4 cm). While burlapped and control twigs contained 16 and 62 ppm Na^+, respectively, all spray-treated twigs contained between 59 and 71 ppm Na^+.

In related investigations, all five chemical sprays resulted in small reductions in injury to twigs of red pine. Except for the Siliconate 51T treatment, all spray-treated twigs contained less

Na^+ and Cl^- than unsprayed twigs. Similar spray treatments applied to five other species (silver maple, lilac, black willow, Austrian pine, and white pine) were ineffective and/or twig samples were insufficient and too variable to obtain meaningful results.

In another study, whole peach trees were sprayed with Folicote, RD 1725 and four new experimental emulsion-based formulations (RD 2033, RD 2034, RD 2035, RD 2036). Subsequently, half of each tree was sprayed four times during the winter with a 2% rock salt solution. RD 2033-treated twigs showed the least injury and accumulated moderately less Cl^- than untreated twigs from either the salted or non-salted sides of the trees. All other treatments were ineffective and, in fact, RD 2034-treated twigs accumulated more Cl^- and Na^+ than the control and had the greatest amount of injury.

The present study confirms that film-forming chemicals reduce build-up of salt in twigs of some roadside trees and provide some protection against salt spray injury. However, because of mild temperatures in recent winters and variability in the results, large-scale or commercial use of these sprays cannot be recommended without further testing.

ACKNOWLEDGEMENTS

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LIST OF TABLES

INTRODUCTION

Application of road salt to major Ontario highways during the winter is a common practice. It has been determined that salt spray is phytotoxic to vegetation in the vicinity of highways (Lumis *et al*. 1973, 1983).

A recent research project (Piedrahita 1987) examined the potential of various film-forming chemical sprays to provide protection against salt spray injury to roadside trees. Of 18 different chemicals tested during a three-year period, five were eventually identified as having the potential to reduce or eliminate salt injury to fruit trees and other roadside vegetation. However, additional field work was required before recommendations could be made concerning the large-scale use and commercialization of these chemicals.

In these investigations, two chemicals, RD 1725 and RD 1726, specially formulated for this project by International Waxes Ltd. of Agincourt, were among the five most promising chemicals. The company felt that an improvement in the coating material could result in an effective protectant for roadside trees, and was particularly interested in the effect of these chemicals on peach trees.

The objectives of the present investigations were:

a) to repeat field and laboratory experiments of Piedrahita (1987) to obtain at least one additional year of data under similar conditions;

b) to evaluate the degree of protection provided by several new emulsion-based films formulated by International Waxes and to determine the durability or integrity of these films during the winter.

MATERIALS AND METHODS

A. Continuing Investigations

Field locations and description of the nine previously studied species along four major highways (Piedrahita 1987) are presented in Table 1.

(i) 'Garnet Beauty' Peach - Lizak Farm

On 9 November, 1987, seven branches were selected on each of 20 'Garnet Beauty' peach trees located on the south side of the Queen Elizabeth Way (QEW) at Lizak Farm. On each tree, branches were either left unsprayed (control), covered with burlap, or sprayed with one of five chemicals (Folicote, RD 1725, RD 1726, Siliconate 51T and Joncryl 1938) prepared according to the manufacturers' recommended dilution rates (Table 2). Each chemical was applied using a 20-L backpack sprayer (Back Pak 20, Plant Products Co. Ltd, Bramalea) to which was added Triton XR surfactant (Rohm and Haas, Ontario) at 2.5 ml/litre of spray mixture. Overspray onto adjacent branches was prevented by covering them with a large polyethylene sheet. The experimental design was a split plot with spray/protective treatments as main plots and rows as sub-plots.

Before spraying, two twigs (30 cm or longer) per tree were removed for analysis of Na^+ and Cl^- background levels. On 11 April 1988, two twigs per treatment branch per tree were similarly sampled for Na^+ and Cl^- content. On 12 May 1988, twig dieback, measured by length of dead tissue from tip to first flower bud was recorded *in situ* on two twigs per treatment per tree.

Na^+ and Cl^- ion contents of dried, ground twigs were determined by the method of Hofstra and Hall (1971).

(ii) Landscape Trees

In mid-November, twigs (three per species per treatment) of apple, silver maple, lilac, black willow, Austrian pine, red pine and white pine (Table 1) were treated as above but without the burlap protective treatment. Twig samples of all these species, except apple, were collected, rated for injury if feasible, and analysed as above for Na^+ and Cl^-. Four to eight trees of each species were treated in a randomized complete block design with each tree serving as a replicate (Table 1).

B. New Chemicals

Twenty-eight 'Madison' peach trees planted in 1979, located alongside the northern service road of the QEW in the orchard of Schenck Farms, St. Catharines, were divided into four replications of seven trees each. Trees were located 45-50 m from the northern edge of the QEW. Although these trees had suffered annually from roadside salt spray as badly or worse than those on the south side of the QEW (Part A), and variously from canker disease, they were properly pruned and had apparently healthy one-year shoots. In early November all trees in this orchard were sprayed with Ferbam as part of the routine management practice of this orchard.

The schedule of twig sampling and spraying of the peach trees is presented in Table 3 along with the prevailing weather conditions during spraying. On 30 November 1987 each whole tree within a replicate was sprayed with one of the following treatments: Folicote, RD 1725, and four new emulsion-based formulations (RD 2033, RD 2034, RD 2035 and RD 2036) (Table 2). One tree in each replicate was left unsprayed as a control treatment.

Between monthly samplings of twigs, a 2% (wt/vol) solution of rock salt was applied to one-half of each tree on the four dates shown in Table 3. Twig samples (1987 growth) were taken from

both unsalted (-salt) and salted (+salt) sides of each tree. Each sample consisted of four 30 cm twigs. The experimental design was a split plot with spray treatments as main plots and salted/non-salted halves of each tree as sub-plots. Data for each sampling date were analysed separately.

In the laboratory, a one cm portion located one third the distance from the short tip was removed from one twig of each sample and prepared for scanning electron microscope (SEM) observation (Piedrahita 1987). Also, two twigs from each treatment within two randomly selected replications were examined under a stereo microscope to visually determine the state or integrity of each spray film. Each twig was examined along its entire length and given a "nail test". A one to two cm fingernail scrape along the twig gave an indication of the presence (streaking) and the relative thickness (accumulation) of the treatment layer. Twig samples were then dried, ground and reserved for Na^+ and Cl^- analysis.

On 10 May 1988, twig injury, expressed as centimeters of dieback from the tip to the first flower bud and also as the percentage of dead flower or vegetative buds per 30 cm twig, was recorded *in situ* on three twigs per treatment in each replication.

RESULTS AND DISCUSSION

A. Continuing Investigations

(i) 'Garnet Beauty' Peach - Lizak Farm

Analysis of variance for row effects (Table 4) showed that in the spring, trees in row 1 (closer to the highway) had consistently more twig dieback and greater contents of Na^+ and Cl^- than trees treated in row 2.

Twigs from the control treatment accumulated the greatest quantities of Cl^- (358 ppm) and exhibited the greatest twig dieback (13.6 cm to first flower bud) (Table 4). In contrast, burlapped twigs accumulated only 58 ppm Cl^- and were the least damaged (5.3 cm dieback). Spray-treated twigs contained between 248 and 290 ppm Cl^- and exhibited intermediate injury, with RD 1726 and Joncryl 1938 showing the least dieback (8.7 and 7.4 cm, respectively). The Na^+ content was least in burlapped twigs (16 ppm), highest in Siliconate 51T-treated twigs (71 ppm) and intermediate in all other treatments, including the control (59-62 ppm).

(ii) Landscape Trees

Data for red pine (Table 5) showed small but significant reductions in twig injury in all spray-treated twigs in comparison to control twigs. Except for the control and Siliconate 51T treatments, spray-treated twigs also contained significantly less Na^+ and Cl^-. The best protection was achieved by RD 1725 and RD 1726, but values were not significantly different at the 5% level according to Duncan's multiple range test.

There were little or no significant differences in the contents of Na^+ and Cl^- in samples of the other species (data not shown). Except for Austrian pine which showed no difference in injury rating regardless of spray treatments, it was difficult to distinguish between injury associated with experimental treatments and that associated with other causes. The deciduous species generally did not yield reliable results because of variability, lack of the required number of suitable samples, and/or progressive deterioration of the plants over time (Table 1). The silver maple trees, for instance, had noticeably deteriorated between fall of 1987 and spring of 1988. As previously reported by Piedrahita (1987), twigs of black willow showed 100% injury regardless of spray treatments.

Unfortunately, apple twigs were unavailable since trees were pruned by the grower before samples could be taken.

B. New Chemicals

(i) Microscopic Examination

After spraying on 30 November 1987, RD 2033, RD 2034 and RD 2035 appeared as relatively thick, white films. RD 2036, RD 1725 and Folicote appeared as translucent or lacquer-coloured films, but were nonetheless clearly discernible when compared to twigs that were unsprayed.

Light microscope examination of twigs sampled on 2 December indicated that the drizzle that occurred soon after spraying (Table 1) did not wash away the spray films. However, as indicated by the "nail test", there was some variability in thickness of the films apparently associated with the early rain and/or with uneven coverage as a result of the windy, cold conditions at spraying time (Table 1). From a practical viewpoint, 30 November appeared to be too late in the season to apply the chemicals because of wet, cold and unfavourable conditions. RD 2033 formed the thickest film which was white and "foamy" in heavily coated areas, perhaps due to excess coverage, and glossy white in more lightly covered areas.

Although most films appeared to be unchanged by 29 December, the surface of RD 2034 and RD 2035 seemed to have changed slightly in appearance and colour. RD 2034 appeared to be glossier with white-coated areas and with thinner coverage on the buds. RD 2035 also appeared to be glossy but transparent; buds appeared to be covered as in early December. There was no apparent difference in the coatings of twigs artificially sprayed or unsprayed with salt.

Surfaces of twigs on 27 January 1988 appeared to be similar to those on 29 December except that RD 2034 seemed to have a thinner coat than observed at previous sampling times. In samples inspected 23 February, coatings of RD 2034 and RD 2035 seemed thin with apparent bare spots. Deterioration of the films of RD 2034 and RD 2035 over time may be the result of weathering.

On 23 February, the Folicote film on unsalted twigs broke away more easily from the buds, revealing green inner tissue. A few salt-like crystals were present on the surface of artificially salted Folicote-treated twigs as on corresponding twigs of control plants.

At this writing, observations of sprayed twig samples under SEM were still in progress. Results will be summarized and passed on to International Waxes in the near future.

(ii) Chemical Analysis and Injury

Tables 6 and 7 show Na^+ and Cl^- contents, respectively, of twigs of 'Madison' peaches at various intervals between 29 December 1987 and 13 April 1988 at Schenck Farm. Since analysis of variance indicated no interaction between spray treatments and artificial salt spray effects, only main effect treatments are presented.

In all treatments, the Na^+ and Cl^- content increased progressively in the twig tissue during the sampling period. Twigs treated with RD 2033, however, accumulated significantly less Cl^- than the control twigs throughout the sampling period (Table 7). Also the percentage of dead flower buds was least in RD 2033-treated twigs (Table 8). All other spray treatments were ineffective in reducing the content of Na^+ or Cl^- or in reducing injury. In fact, RD 2034-treated twigs accumulated more Na^+ and Cl^- than the controls (Tables 6 and 7) and tended to have the greatest amount of injury in terms of twig dieback and dead flower buds (Table 8). The percentage of dead vegetative buds was not significantly influenced by any of the spray treatments (Table 8).

GENERAL DISCUSSION

Systematic screening by Piedrahita (1987) over a three-year period showed that five chemicals, Folicote, RD 1725, RD 1726, Siliconate 51T and Joncryl 1938 were most consistent in reducing buildup of Na^+ and Cl^- and in alleviating twig injury to either roadside trees exposed to salt sprays, or trees sprayed artifically with salt solution. One-year field tests of these five chemicals along various highways during the winter of 1986-87 resulted in small reductions in salt spray injury to Austrian pine, red pine, white pine and apple (Piedrahita 1987). Results with other deciduous species (peach, apple, silver maple, lilac, elm and black willow) were variable and no consistent effect of the chemicals was detected (Piedrahita 1987).

The present field study conducted during the winter of 1987-88 showed that all of the above five chemicals moderately reduced build-up of Na^+ and/or Cl^- ions in twigs of peach and red pine. In red pine, all spray-treated twigs showed a small reduction in injury similar to the data of Piedrahita (1987). In peach, there was a tendency for all spray-treated twigs to have less twig dieback, but only twigs treated with RD 1726 and Joncryl 1938 had significantly less damage statistically ($\underline{P} \leqslant 0.05$) than the control. As exemplified by the dramatic reduction in both salt build-up and injury, the burlap method of

protection produces excellent results and has been utilized on a small scale for years at Lizak Farm. However, this method is not practical on a large scale.

The study conducted at the Schenck Farm indicated that one of the four new experimental formulas, RD 2033, suppressed Cl^- levels throughout the winter and reduced flower bud injury. In contrast, the very similar RD 2034 formula had the opposite effect, suggesting a dramatic loss of the physical integrity of this film. Stereo light microscope examination of the sprayed twigs as the winter season progressed suggested that film thickness and resistance to weathering may indeed play an important role. It is tempting to speculate that RD 2034 may have reacted chemically with the salt in some way to cause a rapid deterioration of the film.

CONCLUSION

The results of the present study confirm that various film-forming chemicals applied to roadside trees in the fall have the capacity to reduce salt build-up in twigs and may provide some degree of protection against salt spray injury.

Our results are encouraging, but large-scale or commercial use of any one or more of the chemicals tested thus far cannot be recommended without further testing for the following reasons:

(a) These chemicals have not been studied for their effectiveness under relatively severe winter conditions. Winter temperatures during the past four years have been relatively mild and 1987-88 has been the mildest since 1984-85 (Table 9). In fact, winter damage in fruit tree areas was far below average this past winter (Anonymous 1988). While less salt was applied during 1987-88 on the QEW in the vicinity of both Lizak Farm and Schenck Farm than during 1986-87, the reverse situation was true at the other two experimental sites along Highways 400 and 401 (Table 10). To increase the scope of data gathering, some investigations could be conducted under more controlled experimental outdoor conditions using more concentrated solutions of artifically applied salt sprays.

(b) Results obtained so far have shown a large variability and should be interpreted with some caution. For instance, because of inherent differences associated with weather conditions, differences in age and physiology (health) of plant material and differences in cumulative exposure to highway salt spray, future investigations should take a more long term perspective and be carefully planned to take these factors into account. For example, larger numbers of replications and larger, more representative twig samples would be desirable in future work. Due to significant fluctuations and sudden changes in fall weather, further studies should investigate influence of the date of applications. Perhaps chemicals could be 'tested' under simulated conditions before use to determine their integrity after they are exposed to water (rain) and/or low temperatures. Future research could also use different coloured films for greater visibility in monitoring their integrity during the season, and could determine how films affect bud coverage during the winter and bud emergence in spring.

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Table 1. Description of field locations and species sampled for continuing experimentation November 1987 - May 1988.

Location	Species	No. of trees	Date Sprayed 1987	Date twigs harvested 1988	Comments
QEW Lizak Farm 14 km west of Vineland	Apple 'Yellow Delicious'	16	23 Nov.; morning 10°C, overcast	-	Row of 18-yr-old trees along chainlink fence bordering the highway. Samples unavailable. Trees pruned by grower before samples could be taken.
	Peach 'Garnet Beauty'	20	9 Nov.; morning 5°C, calm, cloudy; drizzle in late afternoon	11 April	Two rows of 10 trees alongside the QEW. Row 2 is 36 m away and furthest from the highway; row 1 is 5 m closer to the highway. A row of pear trees separates rows 1 and 2. In front of row 1 (towards the highway) is a buffer row of pear trees (5 m) followed in turn by the above row of apple trees (7 m); a chainlink fence (1 m); a ditch and a merging traffic lane.
HW400 44 km north of 401	Elm	-	-	-	Plants 4-6 m high in very poor condition located 18 m from edge of highway; not suitable for further work.
53 km north of 410	Austrian Pine	8	13 Nov.; morning, 10°C, overcast	13 May	Small stand of variable plants, 1.5-2.0 m high, 14-18 m along highway.
54 km north of 401	Lilac	7	13 Nov., morning, 10°C, overcast	13 May	Bushes (3 m high) in poor and variable condition; insufficient samples, suitable twigs difficult to find; samples selected from only 7 clumps. Bushes located on ridge along eastern side 18-20 m from road.
HW401 1 km west of Guelph Line	Red Pine White Pine	8 8	16 Nov.; morning, 14-16°C, sunny	5 May	Dense stands of trees with both species adjacent to each other; located 30-35 m from south side of highway; white pine 2-3 m high, red pine 6-7 m high.
1 km east of James Snow Parkway	Black Willow	8	13 Nov.; afternoon 13°C, overcast	5 May	Plants 2.5-4.0 m tall in reasonably good condition; 30 m from south side of highway.
	Silver Maple	5	13 Nov.; afternoon 13°C, overcast	5 May	Plants 5-6 m tall in deteriorating condition; samples variable and taken from only 4 trees; 30 m from south side of highway.

Table 2. Rates and description of film-forming chemicals.

Chemical	Dilution	% Solids in solution	Low temp threshold (°C)	Color when dried
Folicote	1:10	5	6 - 8	translucent
RD 1725	1:5	10	4 - 5	translucent
RD 1726	1:3	10	4 - 5	translucent
Siliconate 51T	1:50	10	0	translucent
Joncryl 1938	1:5	8	4 - 5	translucent
RD 2033	1:3	10.6	4 - 5	white
RD 2034	1:3	12.0	4 - 5	white
RD 2035	1:3	11.7	4 - 5	white
RD 2036	1:5	10.0	4 - 5	translucent

Table 3. Schedule of twig sampling and spraying of 'Madison' peach trees at Schenck Farm, 18 November 1987 to 13 April 1988.

Date	Sample/Spray	Comments/weather conditions
18 Nov. 87	Twig sample	One twig from each of four control trees sampled for background Na^+ and Cl^- levels.
30 Nov. 87	Applied spray treatments	Sprays mixed on 27 Nov. (Friday) but too cold for application that day. Sprays kept over the week-end at 4°C. On 30 Nov. (Monday) all solutions appeared to be in suspension, no clogging of nozzles. Trees sprayed by replications between 9:30 a.m. - 3:00 p.m. Weather about 7°C throughout the day; cloudy, overcast, calm. Light drizzle started at 4:30 p.m. and continued for 24 hours overnight and throughout the next day.
14 Dec. 87	2% salt spray	Sprayed 1 - 4 p.m., weather 2°C, cloudy and windy. Freezing rain the next morning may have washed away salts from this spray.
29 Dec. 87	Twig sample	
12 Jan. 88	2% salt spray	Sprayed 9 a.m. - 12 noon. Weather 7°C, cloudy.
27 Jan. 88	Twig sample	
9 Feb. 88	2% salt spray	Sprayed 9 a.m. - 12 noon. Weather -7°C, clear, little or no wind.
23 Feb. 88	Twig samples	
8 Mar. 88	2% salt spray	Sprayed 9 a.m. - 12 noon. Weather 3°C, overcast, sunny periods, slight wind.
24 Mar. 88	Twig samples	
13 Apr. 88	Twig samples	

Table 4. Effect of various film-forming sprays on twig dieback and Na^+ and Cl^- ion content[z] in twigs of 'Garnet Beauty' peach trees at Lizak Farm.

Spray treatment or row effects	Twig dieback (cm)[y] to first flower bud	ppm Na^+	ppm Cl^-
	Spray treatment effects		
Control	13.6 a[x]	62 b	358 a
Folicote	10.0 abc	62 b	290 b
RD 1725	11.8 ab	64 ab	269 b
RD 1726	8.7 bcd	67 ab	278 b
Siliconate 51T	12.3 a	71 a	285 b
Joncryl 1938	7.4 cd	59 b	248 b
Burlap	5.3 d	16 c	58 c
	Row effects		
Row 1[v]	13.2 a	64 a	295 a
Row 2	7.5 b	50 b	215 b

z Background levels: 7 ppm Na^+; 28 ppm Cl^-.

y Analysis of variance conducted on values transformed to log x + 1.

x Values followed by the same letters are not significantly different from each other at the 5% level according to Duncan's multiple range test.

v Closer to highway.

Table 5. Effect of various film-forming sprays on twig injury and Na^+ and Cl^- content[z] in twigs of red pine located along Highway 401.

Spray treatment	Twig injury rating[y]	ppm Na^+	ppm Cl^-
	Red pine		
Control	3.3 a[x]	22 a	181 a
Folicote	2.3 b	14 b	126 b
RD 1725	1.9 b	11 b	109 b
RD 1726	1.8 b	10 b	109 b
Siliconate 51T	2.5 b	22 a	181 a
Joncryl 1938	2.0 b	14 b	126 b

[z] Background levels: 6 ppm Na^+; 24 ppm Cl^-.

[y] Scale: 1 = no damage to needles; 5 = all needles damaged

[x] Values followed by the same letters are not significantly different from each other at 5% level according to Duncan's multiple range test.

Table 6. Effect of various film-forming sprays on Na^+ ion content[z] in twigs of 'Madison' peach trees at Schenck Farm.

Spray treatment or salt effects	Sampling Dates					
	29 Dec.	27 Jan.	23 Feb.	22 Mar.	13 Apr.	Overall Mean
			Spray treatment effects			
Control	6.8 a[y]	18 a	37 b	42 ab	44 b	30 b
Folicote	7.4 a	21 a	40 b	47 ab	41 b	31 ab
RD 1725	7.7 a	19 a	37 b	45 ab	45 b	31 ab
RD 2033	5.6 a	17 a	34 b	39 b	37 b	27 b
RD 2034	9.1 a	26 a	52 a	60 a	58 a	43 a
RD 2035	7.2 a	23 a	41 b	49 ab	46 b	33 ab
RD 2036	7.7 a	18 a	37 b	41 b	43 b	29 b
			Salt spray effects			
- salt	1.3 b	10 b	28 b	33 b	34 b	21 b
+ salt	13.4 a	30 a	52 a	60 a	56 a	42 a

[z] Background level: 0.2 ppm Na^+.

[y] Values followed by the same letters are not significantly different from each other at the 5% level according to Duncan's multiple range test.

Table 7. Effect of various film-forming sprays on Cl^- ion content[z] in twigs of 'Madison' peach trees at Schenck Farm.

Spray treatment or salt effects	Sampling dates					
	29 Dec.	27 Jan.	23 Feb.	22 Mar.	13 Apr.	Overall Mean
			Spray treatment effects			
Control	28 b[y]	89 bc	174 bc	213 b	207 bc	142 b
Folicote	31 ab	95 bc	180 bc	224 b	199 bc	146 b
RD 1725	33 ab	89 bc	175 bc	211 b	217 b	145 b
RD 2033	24 b	76 c	154 c	185 b	180 c	124 c
RD 2034	41 a	121 a	253 a	285 a	285 a	197 a
RD 2035	32 ab	109 ab	199 b	235 b	220 b	159 b
RD 2036	35 ab	89 bc	181 bc	212 b	210 bc	145 b
			Salt spray effects			
- Salt	26 b	82 b	167 b	193 b	188 b	131 b
+ Salt	38 a	109 a	209 a	254 a	246 a	171 a

[z] Background level: 15 ppm Cl^-.

[y] Values followed by the same letter are not significantly different from each other at the 5% level according to Duncan's multiple range test.

Table 8. Effect of various film-forming sprays on twig dieback and bud injury of 'Madison' peach trees at Schenck Farm.

Spray treatment or salt effects	Twig dieback (cm)^z to first flowerbud	% Dead buds per 30 cm^y	
		Flower	Vegetative
	Spray treatment effects		
Control	6.0 bc^x	46 ab	9 a
Folicote	5.9 bc	40 ab	28 a
RD 1725	11.0 ab	33 bc	9 a
RD 2033	4.1 c	13 c	7 a
RD 2034	7.9 abc	58 a	17 a
RD 2035	8.2 abc	45 ab	19 a
RD 2036	16.5 a	26 bc	7 a
	Salt spray effects		
- Salt	7.5 a	32 a	7 b
+ Salt	9.6 a	38 a	18 a

^{z} Analysis of variance conducted on values transformed to log x + 1.

^{y} Analysis of variance conducted on values transformed to arcsin $\sqrt{x}$.

^{x} Values followed by the same letter are not significantly different from each other at the 5% level according to Duncan's multiple range test.

Table 9. Weather data at Vineland Station, Ontario during the winter months of 1984-88.

Year	December	January	February	March
		Average Mean Daily Maximum Temperature (°C)		
87-88	4.3	0.8	0.0	5.7
86-87	2.6	-0.1	0.2	6.1
85-86	-0.2	-0.2	-2.0	6.4
84-85	5.0	-2.8	-0.3	6.1
70 year mean	2.0	-0.5	0.0	4.3
		Average Mean Daily Minimum Temperature (°C)		
87-88	-1.2	-7.0	-7.8	-2.9
86-87	-2.1	-5.7	-6.4	-1.8
85-86	-6.2	-6.7	-7.0	-2.1
84-85	-2.0	-8.7	-7.1	-1.9
70 year mean	-4.4	-7.3	-7.1	-3.0
		Average Mean Daily Temperature (°C)		
87-88	1.6	-3.1	-3.9	1.4
86-87	0.3	-2.9	-3.1	2.2
85-86	-3.2	-3.4	-4.5	2.1
84-85	1.5	-5.8	-3.7	2.1
70 year mean	-1.2	-3.9	-3.6	0.1
		Rainfall (mm)		
87-88	51.6	13.6	30.6	33.4
86-87	82.2	4.2	11.8	42.2
85-86	17.4	39.2	39.6	50.8
84-85	64.4	5.2	32.0	92.0
70 year mean	38.8	29.6	30.4	47.0
		Snowfall (mm)		
87-88	21.8	8.8	30.8	5.4
86-87	14.0	43.6	5.2	38.2
85-86	29.2	20.6	48.2	10.4
84-85	29.4	30.8	41.8	26.4
70 year mean	25.1	29.8	27.8	18.6
		Total Precipitation (mm)		
87-88	73.4	22.4	61.4	38.8
86-87	96.2	47.8	17.0	80.4
85-86	46.6	59.8	87.8	61.2
84-85	93.8	36.0	73.8	118.4
70 year mean	63.9	59.4	58.2	65.6

Table 10. Roadside salt applications in vicinity of experimental sites.

Month	tonne/km 1986-87	tonne/km 1987-88	No. Applications/mo 1986-87	No. Applications/mo 1987-88	Total tonnes/mo 1987-87	Total tonnes/mo 1987-88
			QEW, Lizak Farm			
Nov.	0.22	0	15	0	2.25	0
Dec.	0.22	0.18	21	11	4.62	1.98
Jan.	0.22	0.18	54	12	11.88	2.16
Feb.	0.17	0.19	10	40	1.70	7.60
Mar.	0.16	0.18	5	4	0.80	0.72
Total	0.92	0.73	105	67	21.25	12.46
			QEW, Schenck Farm			
Nov.	0.24	0	9	1	2.16	0.04
Dec.	0.22	0.21	13	22	2.86	4.62
Jan.	0.24	0.22	71	26	17.04	5.72
Feb.	0.22	0.22	16	44	3.52	9.68
Mar.	0.21	0.22	7	7	1.47	1.54
Total	1.13	0.91	116	100	27.05	21.60
			Highway 400			
Nov.	0.16	0.23	25	29	4.00	6.67
Dec.	0.15	0.23	45	46	6.75	10.58
Jan.	0.15	0.26	49	28	7.35	7.28
Feb.	0.15	0.27	23	46	3.45	12.42
Mar.	0.15	0.31	19	22	2.85	6.82
Total	0.76	1.30	161	171	24.40	43.77
			Highway 401			
Nov.	0.16	0.16	12	5	1.92	0.80
Dec.	0.20	0.19	32	16	6.40	3.04
Jan.	0.20	0.20	50	24	10.00	4.80
Feb.	0.20	0.19	14	66	2.80	12.54
Mar.	0.16	0.19	8	15	1.28	2.85
Total	0.92	0.93	116	126	22.40	24.03